DOCUMENT RESUME

ED 179 792 CE 023 547

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TITLE Mathematics and Solar Energy. Solar Energy Education Project.
INSTITUTION Howell Township Board of Education, N.J.
SPONS AGENCY New Jersey State Dept. of Education, Trenton. Div. of Vocational Education.
PUB DATE [79]
NOTE 21p.; Not available in paper copy due to light and broken type: For related documents see CE 023 548-550

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Career Awareness: *Energy: Junior High Schools: Learning Modules: *Mathematics Materials: Secondary Education: Secondary School Mathematics: Solar Radiation

ABSTRACT

This learning module for use with junior high school students offers some basic career awareness in the energy field while covering some basic principles and aspects of energy use, such as vocabulary, basic electricity, energy efficiency, and home utility meter reading. Math problems are offered in volume and surface area, energy efficiency, electrical circuits, and work units (horsepower), accompanied by general commentary on occupations that might need such skills. (CP)

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MATHEMATICS AND SOLAR ENERGY

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Solar Energy Education Project

CE023 791

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Solar energy is a recent resolve to our energy crisis here in the United States. The impact of this form of energy is important, not only to us, but to future generations. The importance of basic mathematics is equally important in trying to solve efficient methods of employing such uses of energy. Our students should not only be made aware of the importance of alternative energy sources but also the skills needed in effectively employing them.

This unit is designed to show the students the need to use their basic math skills in solving some related problems in the energy field.

Our children are our greatest resource. If we fail to teach them the basic knowledge they require to survive in the future, then we have failed. But, we can only show them the way. However, they must <u>see</u> the need and be able to carry it to a successful end.

OBJECTIVES

1. The students will identify vocabulary associated with the field of energy.
2. The students will learn to solve problems dealing with volume and surface area.
3. The students will be made aware of and be acquainted with careers related to the energy field.
4. The children will use scale drawing techniques to construct a model.
5. The students will employ formulae in solving problems related to energy problems.

ACTIVITIES

1. Using the list of vocabulary words and their math book (or any resource book necessary) have the students define as many, if not all, the words they can. They can work in teams and the first team to correctly identify the most words win.
2. The Word Sleuth activity.
3. Use the career worksheets on the Electrician. Solve all math problems.
4. Using the Holt Math Book, (eighth grade) pp. 314 to 319; teach the formulae for volume and surface area and related problems in the text.
5. Use the career worksheets on the Meter Reader and related activities on determining electric bill.
6. Using scale drawing methods, construct a model of a building employing solar heat. (May be a flat or 3 dimensional construction) Holt Math, 8th grade pp. 302, 303 for scale drawings.

   (Time permitting....this may be an optional activity)
7. Worksheet 2 on computations using the powers of 10, scientific notation, surface area, problem solving and related formulae.

PRE-POST TEST

Name _____

Answer True or False:

1. The knowledge of basic math facts is not all that important to the study of solar energy. _____

2. Formulae relating to area and cubic measures are used in determining the dimensions and volume of solar constructions. _____

3. In order to understand some concepts of energy saving devices, basic knowledge of electricity is required. _____

4. Solar energy offers the potential for decentralized power production. _____

5. "All fuels are solar energy". _____

Define the following:

1. volume _____

_____

2. surface area _____

_____

3. resistor _____

_____

4. BTU _____

_____

5. ambient temperature _____

_____

Solve the following:

1. Find the total resistance (R_t) of resistors in a series connection. Three resistors are wired in series in a direct current power line to drop the voltage to an electric boiler. R_1 = 15 ohms; R_2 = 25 ohms; R_3 = 18 ohms; and R_4 = 30 ohms. (Hint: find the sum of all resistors (R) in the circuit)

2. The surface area of a cylinder is the area of the bases plus the product of the circumference and the height. Find the surface area of this figure.

3. One cubic foot holds about 7.5 gallons of water. A cylindrical tank is 5 feet high, and has a diameter 2 feet long. About how many gallons of water does the tank hold?

List at least 5 related occupations in the energy field:

1. _____
2. _____
3. _____
4. _____
5. _____

WORKSHEET 2

HOW TO USE MATH SKILLS

1. Assuming that the solar radiation received outside the earth's atmosphere is $0.14/cm^2$, and the energy in the form of light that is emitted by the sun is 4×10^{20} megawatts. The distance from the earth to the sun is 1.5×10^8km. The radius of the earth is 6.3×10^3km. If the average amount of energy that falls on the earth's surface is 0.07 watts/cm^2, how efficient is the earth's atmosphere at transmitting solar energy? What happens to the energy that does not get to the earth's surface?

2. By the year 2000, the United States will consume $10{,}000 \times 10^9$ kilowatt/hr. of electrical energy. Assuming that the United States is 3000 miles by 1000 miles, what is the surface area of the United States in square miles? There are 2.59×10^9 cm^2 $mile^2$. What is the surface area of the United States in square centimeters?

   Brainteaser

   If one percent of the surface of the United States were used to convert solar energy to electrical energy, how much energy would be available? (The solar energy at the earth's surface is 0.07 watts/cm^2.) If the efficiency of conversion is one percent, could the energy needs of the United States be satisfied in the year 2000 by solar energy?

VOCABULARY

ampere	the practical unit of electrical current, being that produced by one volt acting through a resistance of one ohm.
watts	a unit of power or activity, to the work represented by a current of one ampere under a pressure of one volt.
ohms	the practical unit of electrical resistance, being the resistance of a circuit in which a potential difference of one volt produces a current of one ampere.
surface area	the total area of the surface of a solid
BTU	British Thermal Unit--The quantity of heat required to raise the temperature of one pound of water one degree F. at or near its point of maximum density.
energy	capacity for performing work.
resistor	they resist the flow of electrical current.
kilowatt	a unit of power, equal to one thousand watts
ambient temperature	encompassing on all sides
cubic	having the form of a cube; three dimensional; with a unit of length denoting the volume of a cube, etc.
voltage	electrical potential or potential difference expressed in volts.
current	a movement of electricity analogous to the flow of a stream of water, also, the rate of such movement.
fossil fuel	any rock, mineral, or other object dug out of the earth.
photovoltaic cells	photoelectric; designating a photoelectric cell in which light causes the generation of an electromotive force.
photosynthesis	synthesis of chemical compounds effected with the aid of radiant energy, especially light.

ANSWER SHEET

PRE-POST TEST

1. False
2. True
3. True
4. True
5. True

Define:

1. volume--space occupied, as measured by cubic units.
2. surface area--the total area of the surface of a solid.
3. resistor--they resist the flow of electrical current.
3. BTU--British Thermal Unit--The quantity of heat required to raise the temperature of one pound of water one degree F. at or near its point of maximum density.
5. ambient temperature--encompassing on all sides.

Solve:

1. $R_t = R_1 + R_2 + R_3 + R_4$

   $R_t = 15 + 25 + 18 + 30$

   $R_t = 88$ ohms

2. Surface area = $2\pi r^2 + 2\pi rh$

   = 835 square inches

   $2\pi r^2 + 2\pi rh$
   $2(3.14)7^2 + 2(3.14)(7)(12)$
   $2(3.14)49 + 2(3.14)(84)$
   $2(153.86) + 2(263.76)$
   $307.72 + 527.52$
   $835.24 = 835$ sq. in.

3. about 118 gallons Use $V = \pi r^2 h$

   $V = 3.14(1)^2(5)$

   $V = 3.14(5)$

   $V = 15.70$ cu.ft $\rightarrow 15.70 \times 7.5 = 117.750 = 118$ gal.

OCCUPATIONS

electrician
meter reader
chemist
nuclear physicist
engineer (stationary, marine)
trades, technicians, laborers, in the field of electronics

HOW TO USE MATH SKILLS WORKSHEET 2

1. The efficiency is 50 percent. Energy that does not get to the earth's surface stays in the atmosphere.

2. Surface area of U.S. in square miles - 3×10^6 sq. miles
   Surface area of U.S. in square centimeters -- $3 \times 10^6 \times 2.59 \times 10^9$
   7.77×10^{15} sq. cm. per mile

BRAINTEASER

a. 7.8×10^{13} available cm^2 to absorb solar energy

b. $\frac{5.46 \times 10^{12}}{10^3} = 5.46 \times 10^9 \times 10^{-2}$ (efficiency of conversion)
   5.46×10^7 Kilowatts available (NO)

Construction Cluster

ELECTRICIAN

Our modern society is quite dependent on electricity. Much has been learned about electricity since it, as a form of energy, was discovered. The number of related professions, trades, technicians, laborers, etc. in the field of electronics is quite large and the various industries directly dependent on electricity and electronic technology would indeed be all inclusive.

The objective of this lesson is to give you some fundamental notions as to how to measure electric current. No, you have not read incorrectly since electricity must be measured. Although we cannot see electricity, we do know of its existence and it can be measured.

The first fundamental idea we encounter is a resistor (as the name implies, they resist the flow of electrical current). At times resistors are placed in series in an electrical circuit. This simply means that they are placed one after the other (see fig. 1).

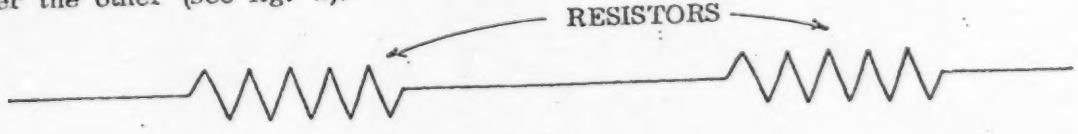


fig. 1

When electricians show an electric circuit, they draw what is called a schematic of the circuit. The straight line in fig. 1 represent the wires and the broken line (/\/\/\ ) represents a resistor. Figure 1 shows only part of a schematic.

Activity

To find the total resistance R_t of resistors in a series connection, the electrician simply finds the sum of all resistors in the circuit. The formula is:

$$R_t = R_1 + R_2 + R_3$$

Three resistors are wired in series in a direct current (D.C.) power line to drop the voltage to an electric boiler. R_1 = 15 ohms (ohms is the unit measure for resistance), R_2 = 25 ohms, R_3 = 18 ohms and R_4 = 30 ohms.

What is the total resistance?

$R_t = R_1 + R_2 + R_3 + R_4$

$R_t = 15 + 25 + 18 + 30$

$R_t = 88$

Conclusion: the total resistance is 88 ohms

Solve the following:

1. Five resistors are wired in series across the output of a D.C. generator to act as voltage dividers. Find the total resistance, if R_1 = 35 ohms, R_2 = 30 ohms, R_3 = 27 ohms and R_4 = 42 ohms.

2. To allow for the proper voltage drop a total resistance, R_t of 130 ohms is needed. What is the value of the fourth resistor, if R_1 = 38 ohms, R_2 = 45 ohms and R_3 = 25 ohms?

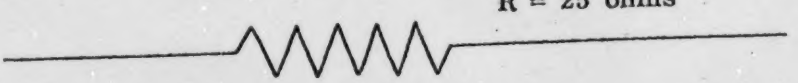
3. Suppose you were required to wire three electric light bulbs in series. Each of the lamps has a resistance of 23 ohms. You also connect a 45 ohm resistor in series with the lamps. What is the total resistance?

A formula which is used many times in electrical work is E = I x R (called Ohm's Law). This means if you know the amount of current (I) and multiply it by the resistance (R), the product will be the voltage. Voltage is also known as electrical pressure, electromotive force, or EMF.

Unit measure for current, I, is amperes
Unit measure for resistance, R, is ohms
Unit measure for voltage, E, is volts

What is the voltage drop across a resistor if the resistance is 25 ohms and the current is 10 amperes (see fig. 2)?

R = 25 ohms

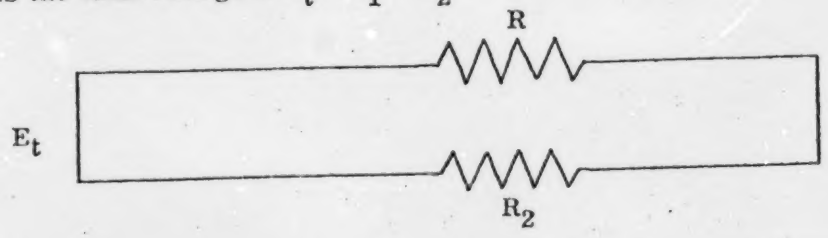


$E = I \times R$
$E = 10 \times 25$
$E = 250$

Conclusion: the voltage drop is 250 volts.

Two resistors R_1 and R_2 are connected in series and across a D.C. voltage source in order to supply different voltages to a distribution panel. What is the voltage drop across each resistor if $R_1 = 22$ ohms, $R_2 = 30$ ohms and $I = 6$ amperes.

What is the total voltage if $E_t = E_1 + E_2$?



$E_1 = I \times R_1$
$E_1 = 6 \times 22$
$E_1 = 132$

$E_2 = I \times R_2$
$E_2 = 6 \times 30$
$E_2 = 180$

$E_t = E_1 + E_2$
$E_t = 132 + 180$
$E_t = 312$

Conclusion: The voltage drop across R_1 is 132 volts.
The voltage drop across R_2 is 180 volts.
The total voltage is 312 volts.

4. Three resistors are series connected similar to example two. $R_1 = 28$ ohms, $R_2 = 23$ ohms and $R_3 = 35$ ohms. The current is 6 amperes.

   a. What is the voltage drop across each resistor?

   b. What is the total voltage?

   c. What is the total resistance in the circuit?

   d. Can you find the total voltage without finding each voltage drop?

You can calculate the power by multiplying the current by itself and then multiplying again by the value of the resistance. If P represents the power, measured in watts, then $P = I \times I \times R$. Since $E = I \times R$, then $P = I \times E$ is another formula to find power.

An electric toaster whose hot resistance is 12 ohms has a current of 9 amperes flowing through it. How much is being used?

$P = I \times I \times R$
$P = 9 \times 9 \times 12$
$P = 972$ watts

or

$E = I \times R$
$E = 9 \times 12 = 108$
$P = I \times E$
$P = 9 \times 108$
$P = 972$ watts

Conclusion: The measure of power is 972 watts.

5. What is the power of an electric motor taking 10 amperes on a 220 volt line?

6. An electric drill takes 4 amperes at a voltage of 120. What is its power?

7. An automobile engine starter takes 300 amperes at 12 volts and what is its power?

8. An electric motor running on a 220 volt line takes 30 amperes. What is its approximate horsepower? One horsepower equals 746 watts, therefore, Horsepower (hp) $= \frac{\text{watts}}{746} = \frac{E \times I}{746}$.

$$hp = \frac{E \times I}{746} \qquad hp = \frac{220 \times 30}{746} = \frac{6600}{746} \qquad hp = 8.8$$

Conclusion: The motor is approximately a 9 hp motor.

9. Find the hp of the motor in problem 5.

10. Find the hp of the drill in problem 6.

11. Find the hp of the starter in problem 7.

12. Find the amperes necessary to run the following household appliances on 120 volts.

a. a 120 watt bulb
b. a 720 watt toaster
c. a 1080 watt motor
d. a 200 watt bulb
e. a 360 watt fan

ANSWERS:

1. 134 ohms

2. 22 ohms

3. 114 ohms

4. a) 168, 138, 210
   b) 516 volts
   c) 86 ohms
   d) Yes, multiply total resistance by 6

5. 2200 watts

6. 480 watts

7. 3600 watts

8. 3 hp (2.9)

9. 1 hp (.64)

10. 5 hp (4.8)

11. a) 1
    b) 6
    c) 9
    d) 1.7
    e) 3

SKILL AREAS:

Whole Numbers: addition, subtraction, multiplication and division (divisor up to 3 digits)

Public Service Cluster

METER READER

In order to assess homeowners for their use and consumption of gas, electric and water, their home meters or gauges must be read and the figures accurately recorded on a regular basis. The persons who provide this important public service are the meter readers. The readings are recorded and the homeowner is then sent a bill reflecting the amount owed by the consumer. It is important that this service be performed carefully as the payments are based on reliable information registered by the meter reader.

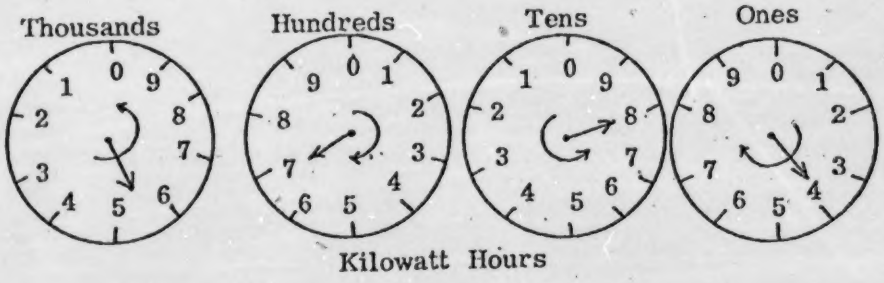
The electric meter measures the amount of electricity used in kilowatt hours. Gas and water consumption are measured in units of cubic feet. You can see, therefore, that the cost depends on which public service is being measured. Persons interested in this career area would need gauge reading experience, basic mathematics and measuring skills.

In the following activity you will simulate the work of a meter reader. The activity will also ask you to solve some problems involving the consumer's costs for these public services.

Activity

Electric Meter Reader — Every home depends on the power source of electricity. An electric meter measures this consumption of electricity in kilowatt-hours (KWH).

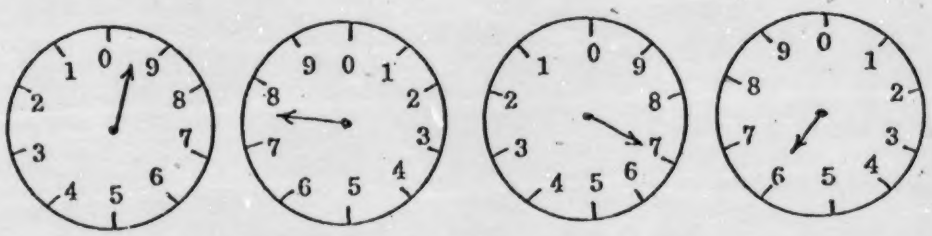
Example:



The kilowatt hours are recorded on the dials. You read the dials from left to right. If the pointer is between two numbers, use the previous number.

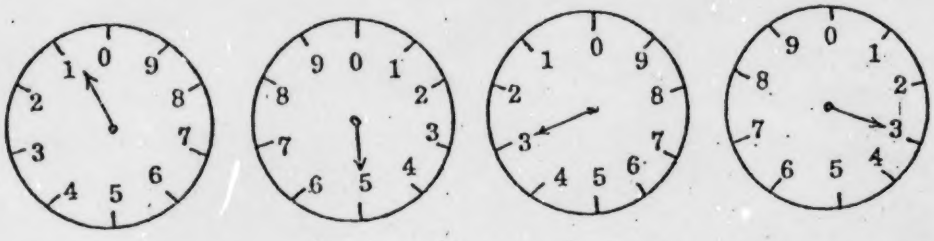
This example reads 5784 KWH

1. Complete the following electric meter reading:

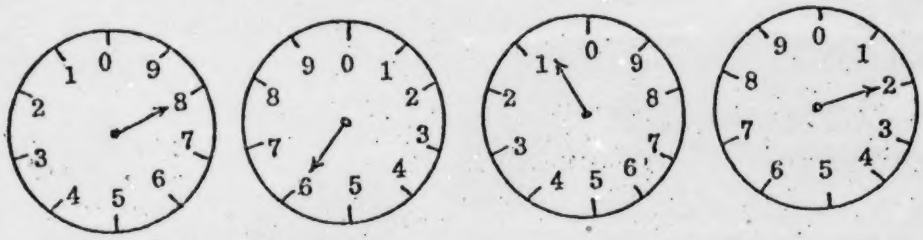


1. Meter reading is 17.

2. Meter reading is _____.

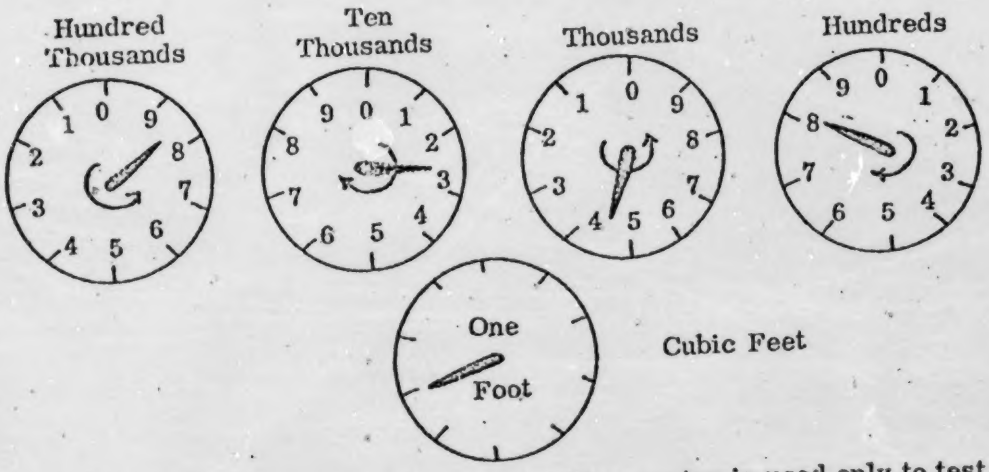


3. Meter reading is_____.



Gas Meter Reader — Not all homeowners have gas service. However, natural gas is a popular source of energy for the home. Gas consumption varies greatly as to whether the household cooks and/or heats with gas. Gas is measured in units of 100 cubic feet. This is symbolized by CCF.

Example:

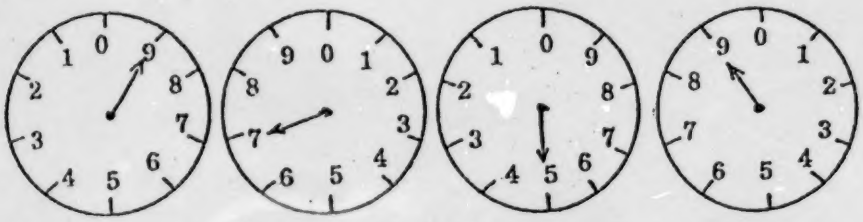


The four top dials are the readings. The bottom meter is used only to test accuracy of the meters. Each point on this dial is 1CCF or 100 cubic feet. One complete revolution on the dial located on the far right records 10CCF which is 1000 cubic feet.

This example reading is 8248 CCF, which is 8248 x 100 cu. feet or 824,800 cubic feet.

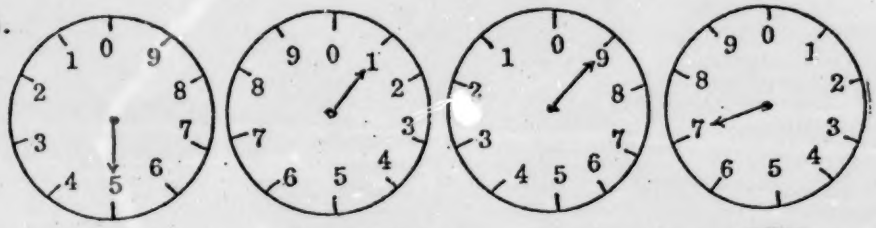
Complete the following gas meter readings:

4.



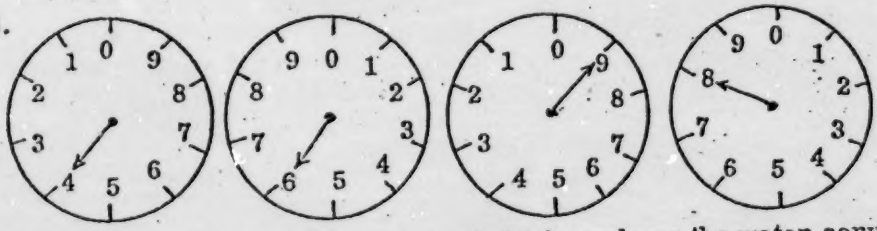
4. Meter reading_____

5.



5. Meter reading_____

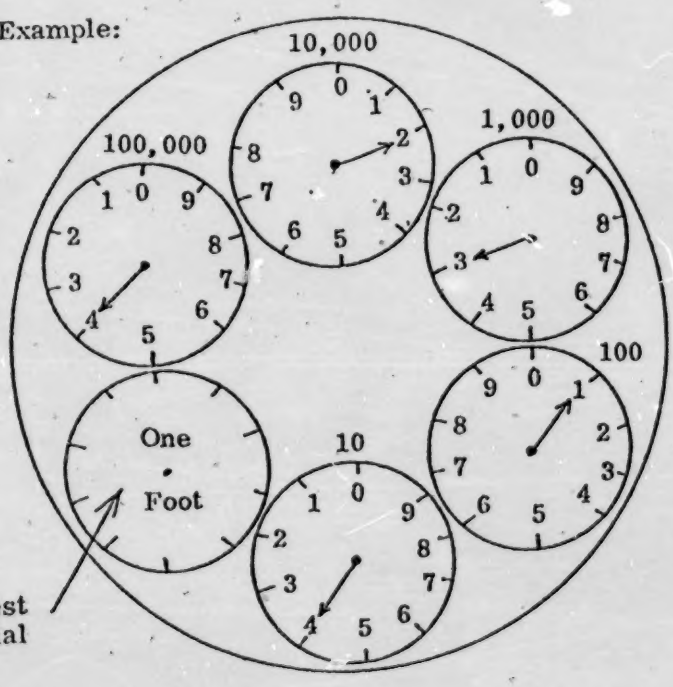
6.



6. Meter reading_____

Water Meter Reader — Every household depends on the water service provided by the community. The amount of water consumed is based on cubic feet. The meter reader always records the lower number when the pointer is between two numbers.

Example:



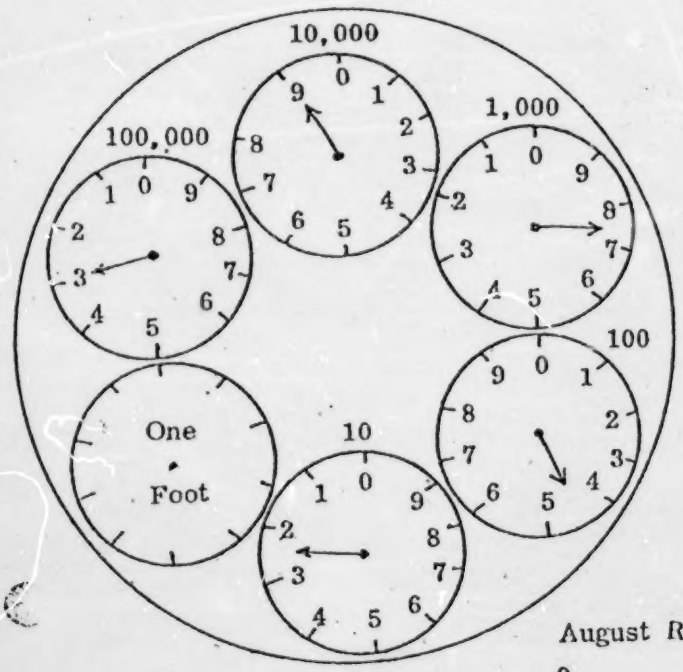
The reading on this water meter is 423,140 cu. ft.

Note: Water company meters do vary in appearance.

Complete the following water meter readings over a nine month period. Water meter readers check the meter every three months.

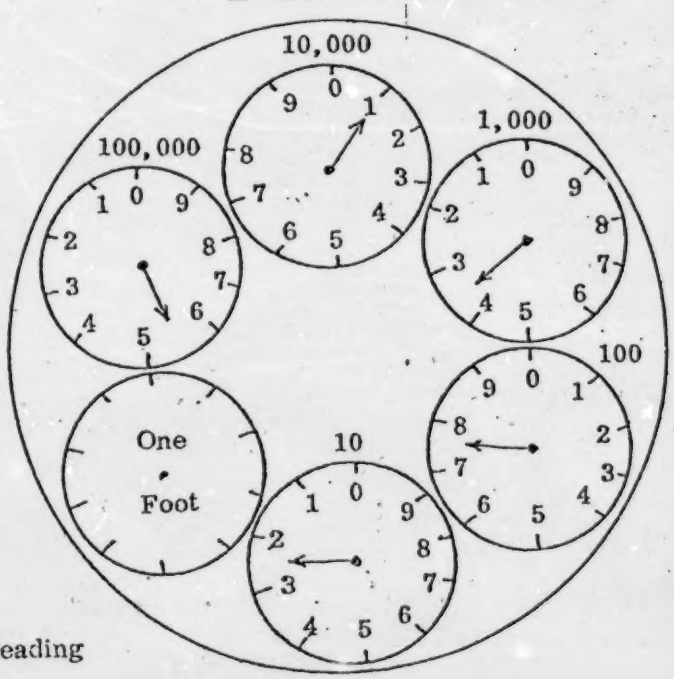
January Reading

7. _____



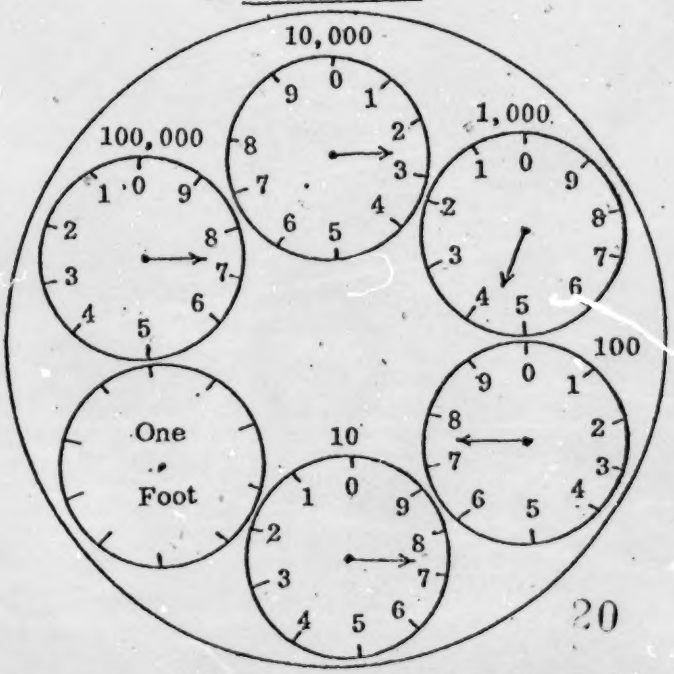
April Reading

8. _____



August Reading

9. _____



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10. Reading your home meters. Locate your water and electric (gas, if possible) meters in your home. Read the meter as you did in the previous examples. Record the readings. After three days, read and record the figures. What is your household's consumption of gas, electric and water?

ANSWERS:

1. 9,776
2. 533
3. 8,602
4. 975,900
5. 519,700
6. 469,800
7. 397,420
8. 513,720
9. 724,770
10. Answers will vary

SKILL AREAS:

Piace value

Gauge reading